PATENT SPECIFICATION

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(21) Application No. 25202/67 (22) Filed 31 May 1967
(31) Convention Application No. 87 712 (32) Filed 25 June 1966 in
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(19) THE PATENT OFFICE LONDON

(54) FRAGMENTATION WARHEAD FOR USE IN MISSILES

(71) We, BOLKOW GMBH, a Company organised and existing under the laws of Western Germany, of Ottobrunn bei Munchen, 8 Munchen 8, Western Germany, and FRANZ RUDOLF THOMANEK, of Austrian nationality, of Sandizell 38 1/4, Landkreis Schrobenhausen/Obb. Western Germany, do hereby declare the invention for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a fragmentation warhead for missiles for use against flying targets, for example ground to air missiles, the warhead being detonated at a short distance from the target by means of a proximity fuse, and the casing of the warhead forming a part of the missile and serving to connect the nose with the body.

In missiles, particularly guided missiles for destroying fast moving targets, it is not possible to provide a large enough explosive charge to ensure that the pressure of the exploding charge is in itself sufficient to destroy the target. For this reason missiles are provided with fragmentation warheads in which the energy of the explosion spreads fragments or particles from the casing of the warhead over the distance separating the warhead from the target. This enables the destructive action to act over a distance of between 10 and 20 metres.

Warheads for missiles are known in which the casing of the warhead is provided on its periphery with a series of hollow charges the axes of which project radially outward into fragments and, despite their small mass, have satisfactory penetrating power over a few metres, owing to their high velocity. The total number of fragments produced depends mainly on the number of hollow charges in the warhead. From one hollow charge about a hundred fragments are produced which will penetrate 4 mm of light metal at 5 metres.

Systematic tests have shown that the destructive probability is governed by the effectiveness and the number of the fragments.

A fragment is regarded as effective if, over the distances obtained in practice, i.e. a few metres, it is able to penetrate a light metal plate of several millimetres in thickness, preferably 4-8 mm.

The object of this invention is to provide a fragmentation warhead for missiles of the type herein set forth which, over a limited distance of 10-20 metres, produces highly penetrative fragments in the maximum possible number and having high effectiveness.

According to this invention there is provided a fragmentation warhead for missiles for use against flying targets, wherein the warhead is provided between the body and nose of the missile and forms an integral part of the missile, and comprises an explosive contained within a casing in which substantially spherical fragments are provided between the explosive and casing wall, which fragments weigh less than 1 p, the average diameter of the explosive charge being more than 25 times the diameter of each fragment.

ERRATUM

SPECIFICATION NO 1430750

Page 1, line 1, (71) *after* We, *insert* MESSERSCHMITT-BOLKOW-BLOHM GESELLSCHAFT MIT BESCHRANKTER HAFTUNG, formerly MESSERSCHMITT-BOLKOW GESELLSCHAFT MIT BESCHRANKTER HAFTUNG, previously

THE PATENT OFFICE
10 September 1976

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This invention relates to a fragmentation warhead for missiles for use against flying targets, for example ground to air missiles, the warhead being detonated at a short distance from the target by means of a proximity fuse, and the casing of the warhead forming a part of the missile and serving to connect the nose with the body.

In missiles, particularly guided missiles for destroying fast moving targets, it is not possible to provide a large enough explosive charge to ensure that the pressure of the exploding charge is in itself sufficient to destroy the target. For this reason missiles are provided with fragmentation warheads in which the energy of the explosion spreads fragments or particles from the casing of the warhead over the distance separating the warhead from the target. This enables the destructive action to act over a distance of between 10 and 20 metres.

Warheads for missiles are known in which the casing of the warhead is provided on its periphery with a series of hollow charges the axes of which project radially outward.

In this case the casing of the warhead is likewise constructed as an integral part of the missile and is capable of absorbing the forces occurring during the transport or handling of the warhead or during flight.

After detonation, the explosive charge produces jets which disintegrate the casing into fragments and, despite their small mass, have satisfactory penetrating power over a few metres, owing to their high velocity. The total number of fragments produced depends mainly on the number of hollow charges in the warhead. From one hollow charge about a hundred fragments are produced which will penetrate 4 mm of light metal at 5 metres.

Systematic tests have shown that the destructive probability is governed by the effectiveness and the number of the fragments.

A fragment is regarded as effective if, over the distances obtained in practice, i.e. a few metres, it is able to penetrate a light metal plate of several millimetres in thickness, preferably 4-8 mm.

The object of this invention is to provide a fragmentation warhead for missiles of the type herein set forth which, over a limited distance of 10-20 metres, produces highly penetrative fragments in the maximum possible number and having high effectiveness.

According to this invention there is provided a fragmentation warhead for missiles for use against flying targets, wherein the warhead is provided between the body and nose of the missile and forms an integral part of the missile, and comprises an explosive contained within a casing in which substantially spherical fragments are provided between the explosive and casing wall, which fragments weigh less than 1 p, the average diameter of the explosive charge being more than 25 times the diameter of each fragment.

Explosive charges with pre-shaped fragments, or explosive charges in which the fragments are formed from the casing are known. Fragmentation charges of this kind have been used for various purposes, for example hand grenades, mortars, fragmentation grenades. These, however, have not provided the desired effect.

SEE ERRATA SLIP ATTACHED

Either the number of fragments is sufficient but their penetrative force inadequate, or the fragments have a large mass to ensure suitable penetrative force, but the number of fragments is insufficient for the desired destructive probability. Warheads of the kind mentioned above are thus unsuitable for use in destroying high speed flying targets.

In designing warheads for destroying flying targets a fact has been hitherto overlooked, that between the solutions already tried there is a range which may be regarded as optimum.

Thorough examination of these satisfactory designs by means of high speed X-ray photographs and penetration measurements have shown that the mass of the particles, need only amounts to fractions of a gramme.

On this basis extensive tests have been carried out with cylindrical explosive charges in which the end surface is provided with an arrangement of steel balls each of 170 mp (millipond ≡ milligramme force) in weight and 3 mm in diameter. In these tests the balls were arranged around charges with concave, plane or convex end surfaces. Saddle-like surfaces with grooves of arcuate cross-section were also tried.

In all cases a high penetrative power was obtained, at a distance of 5 metres, and it was found possible to control the direction of the resulting blast by the shape of the charge surface. Hollow spaces containing balls resulted in the narrowest destruction zone in the direction of the axis of the hollow space and fragment velocities of between 2500 and 1000 metres per second were obtained. The shape of the hollow space resulted in a jet-like blast similar to that produced by the known hollow charge, but with a difference in velocity between the leading fragments, which have the highest, and the trailing fragments which have the lowest velocity.

On the other hand a plane or convex end surface provided with balls resulted in practically equal velocities for all the fragments, amounting to about 2000 metres per second.

After these investigations, larger charges were constructed, the system of balls being provided on the periphery of the explosive charge.

With such charges, which were already nearly of the shape required for a practical warhead, the velocity of the balls and thus their penetrative power underwent a further increase.

If, for example, a light metal plate 4 mm in thickness is to be penetrated, it is possible to obtain this with balls of 64 mp weight, corresponding to a diameter of 2.5 mm, and it was found that with an explosive charge of 2.5 kp the number of balls could be increased to 30,000, with a weight of 1.9 kp. There are thus a considerably greater number of balls in this system than there are fragments produced from the casing of a hollow charge.

On the other hand it is possible, by this principle, to construct the same warhead using balls of weight 270 mp and diameter 4 mm, so that the number of perforations obtained is about 7000, against light metal plates of 8 mm in thickness. In comparison with the warhead having a number of hollow charges, the number of particles is only slightly increased, but the penetrative power is doubled.

To enable a greater destructive effect to be obtained by greater fragment density, a further characteristic of the invention provides that the fragments are in a number of layers on the periphery of the explosive charge. It is true that the multi-layer arrangement adopted for the fragments results in a somewhat lower fragment speed, but this disadvantage can be overcome by increasing the diameter of the explosive charge.

In the construction of a warhead in accordance with the invention it is very important that the shape selected for the explosive charge should be such that the high pressure zone in the oxplosive charge, i.e. that volume enclosed between the detonating wave and the attenuation wave, should be as great as possible.

An explosive charge is particularly effective if the exterior is made up of two concave parts. With this form the direction of propagation of the detonation wave in the explosive charge is such that two annular bursts of fragments, with different spread angles, are produced. With a warhead of this type the arrangement of fragments can be designed so that separate bursts of fragments, differing in their mass, are produced.

In the mathematical analysis of the operation of such warheads or explosive charges, in which the exterior surface is made up of two concave parts, it has been found that fragments of smaller mass and thus lower penetrative power have to be inclined to a greater extent in a forward direction. In the case of flying targets difficult to destroy, it may be of advantage for the generally uniform burst to be subdivided and for a warhead with an explosive charge of the aforementioned type to be adopted.

A further characteristic of the invention provides that the bursts of fragments are to be concentrated in a circle around the warhead. This results in an improvement of the performance, owing to the greater concentration of the burst, so that the strikes on the target are sufficiently close

together to form a cut. This cut effect occurs when the target is pierced with holes in contact with one another, so that the effects of the separate fragments combine, the parts hit thus being not only weakened but destroyed altogether.

Fragments of shapes other than spherical can be used, *mutatis mutandis*.

It is advisable to select shapes fulfilling two conditions:

(1) The pre-shaped fragments should as far as possible rest in contact with one another.

(2) The shape of the fragment undergo as little deformation as possible from spherical on the detonation of the charge and should be without sharp contours, so that air-resistance of the fragments is reduced to a minimum.

Both conditions are fulfilled by facetted balls, the cross section of which may be quadrangular or hexagonal.

As already mentioned, the density of the fragments is of considerable importance in so far as their penetrative power is concerned. For effect at a greater distance, therefore, materials with a higher density than steel are more favourable. It has been found, however, that the pre-shaped fragments are liable to disintegrate during the detonation of the charge, if the material of which they are made is too brittle. This means that steel fragments, for example, must first of all be soft-annealed.

Many unsatisfactory results obtained with fragmentation warheads have been due to the fact that these conditions have not been fulfilled, so that the fragments have disintegrated into smaller pieces. The penetrative force of these pieces. however. is insufficient.

In a further embodiment of the invention. the solid fragments can be replaced by composite fragments. It is not possible to use lead because it undergoes pulverization in the course of the detonation of the explosive charge. It is however possible to use hollow steel balls filled with lead. Fragments of this kind possess the particular advantage of greater density.

In another embodiment of the invention the casing of the warhead consists of a highly resistant material with a smaller mass per unit area than the casing used over the fragments. This construction ensures that it can completely fulfill its supporting and connecting function, without detracting from the penetrative power of the fragments. A warhead casing designed in accordance with the invention therefore exerts no influence on the effect of the fragments.

The destructive effect of a warhead can also be increased by providing a conical hollow space defined by a liner at the front end of the warhead. facing towards the target.

This space in the first place acts as a barrier, so that the explosive force cannot expand too rapidly, while in the second place it produces an axial jet by which the fragments are caused to penetrate the missile nose, and also exerts, if the axis of the missile is directed towards the target, a considerable destructive effect. Such a construction for a warhead is particularly advantageous if the proximity fuse of the missile detonates the explosive charge prematurely, so that the fragments of the explosive charge which are flung out in the form of a conical casing do not reach the target.

The invention will be further described in conjunction with two examples shown in the accompanying drawings.

In the drawings:—

Figure 1 shows a missile with a warhead according to the invention, approaching a target.

Figure 2 is a section through one form of warhead in accordance with the invention.

Figure 3 is a section through another form of warhead according to the invention. and

Figure 4 shows the penetration capacity of spherical fragments as a function of its mass with a given explosive charge.

In the drawings like parts are indicated by like references.

In Figure 1 a missile 1 is shown approaching a target 2. The missile comprises a rear part 1*a* accommodating the propulsion unit, a front part 1*b* containing electronic equipment and a fragmentation warhead 1*c* which connects the two parts 1*a* and 1*b*. On detonation of the explosive charge 3 by means of a proximity fuse (not shown), a conical burst of fragments directed generally forwards is formed, its direction being indicated by the arrows A and B.

Figure 2 shows an example of a fragmentation warhead constructed in accordance with the invention. The explosive charge 3 is generally frusto-conical in shape. Spherical fragments 4 are provided in several layers around the charge the average diameter of which is more than 25 times the diameter of any fragment. As shown, the spherical fragments 4, which are each less than 1p in weight, differ in size, the smaller fragments being positioned close to the explosive charge, while the larger fragments are positioned on the outside. This can be replaced by a system in which the large fragments are situated on the inside and the small fragments on the outside, or a system where all fragments are of equal size and mass can be provided. The

explosive charge 3 and the fragments 4 are surrounded by a casing 5, made for example, of steel, which, at the same time serves to couple the two parts 1*a*, 1*b* of the missile by flanges 6 and 7. The warhead is also surrounded by a covering 10.

The explosive charge 3 is provided at the end directed towards the target, with a conical hollow space and cover 8 of aluminium from which, on detonation, a hollow charge jet is formed.

Figure 3 shows another example in which the casing 5 has two concave parts. This produces two annular bursts of fragments, one of which, indicated by the arrow C, takes a generally lateral direction, while the other burst, indicated by the arrow D, takes a forward direction.

The example shown in Figure 3 is only provided with a single layer of fragments, but the front part of the explosive charge has smaller fragments than the rear part of the charge. The spaces between the fragments, in this example, are filled with explosive. Such spaces could also be filled with an inert substance.

In Figure 4 the penetration powers of spherical fragments of different sizes are given for a certain explosive charge. The penetration power does not increase in proportion to the mass of the fragments, but tends towards a maximum.

If it is borne in mind that the overall mass of the balls in a warhead is fixed, amounting to 2 kp for instance, the number of balls for any given size of ball can be calculated. The larger the balls the smaller their number.

For a given ball size, a crater volume can be calculated from the cross section of the ball and its penetrative power, and this crater volume multiplied by the number of balls gives the total volume of the craters, ΣV_{cr}. As shown by the second curve in Figure 4, the ΣV_{cr} thus determined has a certain maximum, in the example illustrated, for instance, with a ball of 3.6 mm and a mass of 200 mp. On this basis it is possible to select the appropriate size for the balls. This size, as mentioned, is governed by the particular charge adopted, in order to concentrate maximum energy onto the target since, as is known, the crater volume provides a measure of the energy.

WHAT WE CLAIM IS:—

1. Fragmentation warhead for missiles for use against flying targets, wherein the warhead is provided between the body and nose of the missile and forms an integral part of the missile and comprises an explosive contained within a casing in which substantially spherical fragments are provided between the explosive and casing wall, which fragments weigh less than 1 p, the average diameter of the explosive charge being more than 25 times the diameter of each fragment.

2. Warhead in accordance with Claim 1, wherein the fragments are arranged in a number of layers.

3. Warhead in accordance with Claims 1 or 2, wherein the outside surface of the casing is concave.

4. Warhead in accordance with Claim 3, wherein the outside surface of the casing has two concave parts.

5. Warhead in accordance with Claim 4, wherein the groups of fragments are concentrated closely on a circle around the warhead.

6. Warhead in accordance with any one of Claims 1 to 5, wherein the fragments are facetted.

7. Warhead in accordance with any one of Claims 1 to 6, wherein the fragments consist of an outer shell of metal filled with a denser metal.

8. Warhead in accordance with any one of Claims 1 to 7, wherein spaces between the fragments are filled with an inert substance.

9. Warhead in accordance with any one of Claims 1 to 7, wherein spaces between the fragments are filled with an explosive.

10. Warhead in accordance with Claims 1 to 9, wherein the forward end part of the casing is of a material of which the mass per unit area is smaller than the casing.

11. Warhead in accordance with Claims 1 to 10, wherein the forward end of the casing is provided with a conical hollow space.

12. Warhead substantially as herein described with reference to or as shown by the accompanying drawings.

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1 430 750 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*

SHEET 1

Fig.1

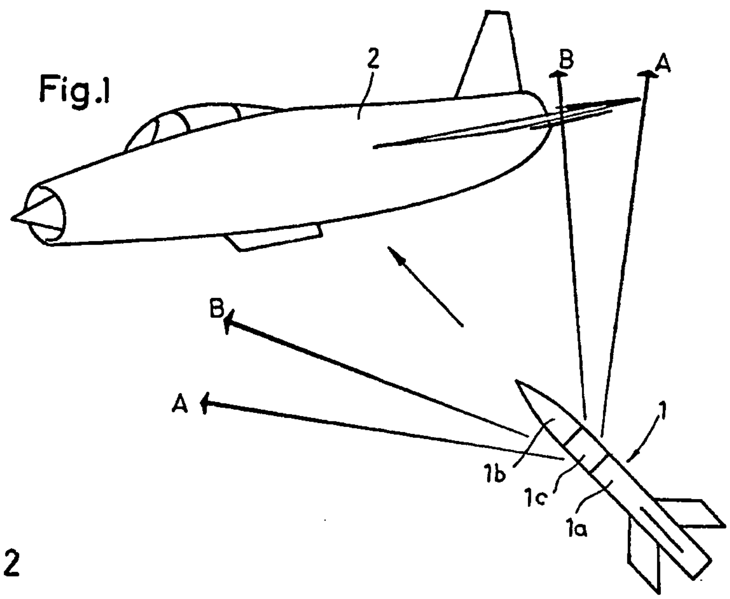
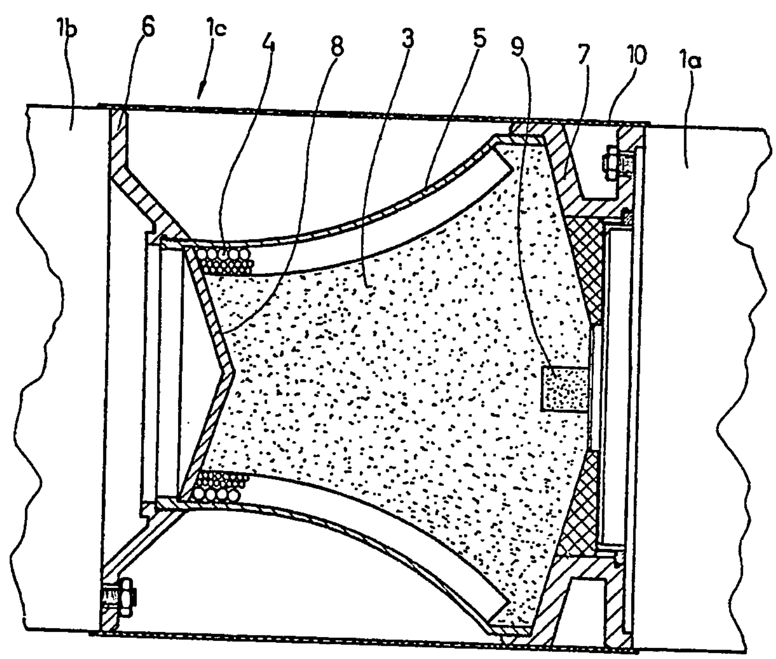


Fig.2



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SHEET 2

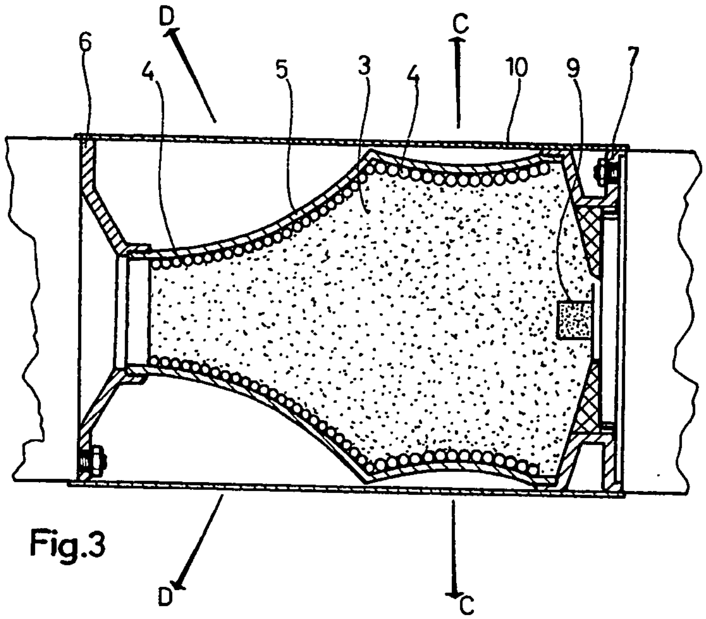

Fig.3

Fig.4